



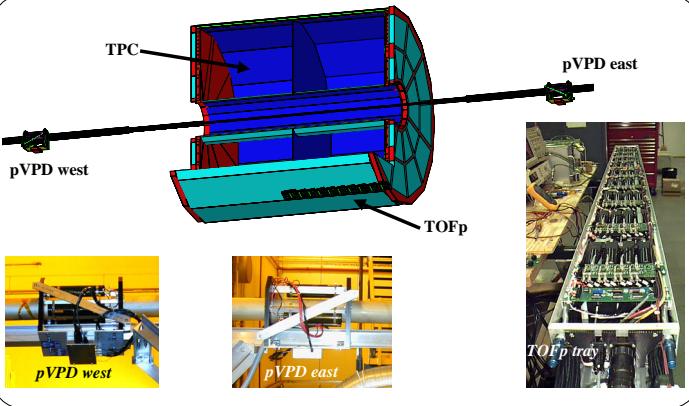
RICE

The STAR Time-of-Flight patch (TOFp/pVVD)

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Particle Identification in STAR

- In the first year (130GeV/c) of STAR particle identification (PID) capabilities were either limited to a low or a high momentum range:
 • dE/dx Bethe-Bloch energy loss in the TPC in the lower momentum range up to ~600 MeV/c
 • decay topology extends the range for K⁻ to ~1.2 GeV/c
 • Cherenkov light emission angle of particles passing through the RICH detector for momenta >2 GeV/c
- In the 2nd year (200GeV/c) of STAR, the Time-of-Flight patch detector aims to provide hadron PID in a limited acceptance that overlaps both the TPC and RICH PID momentum ranges:
 • overall time resolution of ~100ps
 • particle ID for π, K and p
 • start detector: pseudo Vertex Position Detector (pVVD)
 • stop detector: Time-of-Flight patch (TOFp)



TOFp

Technical Specifications

- replaced one of the 120 trays in the CTB layer around the TPC
- tray form factor: 242 x 22 x 9 cm³ at R=2.1m
- 41 slat assemblies, ordered in η-groups of 4 slats (5 slats at η=0)
- slat assembly: 20 x 4 x 2 cm³ BC420 and Hamamatsu R5946
- HV generated locally, a remote control interface
- coverage: azimuthal Δφ = 6°, mid-rapidity coverage 0 < η < 1

Operations

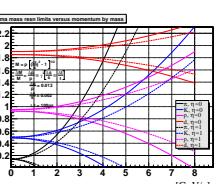
- PMT signals locally amplified and discriminated
- logic and analog signals transferred over ~200ft RG-58/U and re-discriminated
- pVVD coincidence triggers readout and digitization
- Au+Au coincidence level: 2.AND.2 (100% efficient)
- although not designed for p+p, 1.OR.1 coincidence level 60% efficient (13% efficient in offline 1.AND.1)
- digitization in CAMAC with LeCroy 2228A TDCs and 2249A ADCs
- thermocouples along the full signal path

pVVD

Technical Specifications

- two pVVD assemblies, located at ±5.7m from TPC center
- each pVVD assembly consists of 3 cylindrical PMT assemblies
- PMT assemblies: 1.4" Pb converter, 1cm BC420 and 2" R2083
- magnetic shielding against STAR magnetic field (few 100G)
- PMT assemblies symmetrically mounted around the beam
- coverage: ~32% azimuthal, forward rapidity 4.5 < |η| < 5.2
- provides local coincidence trigger and the high resolution start time for the TOFp stops

Functional Requirements



$$m = p \sqrt{\left(\frac{ct}{s}\right)^2 - 1}$$

- momentum p from tracking
- path length s from track extrapolation
- time t from Time of Flight: $t_{\text{start}} - t_{\text{stop}}$

pVVD TOFp

- Δp/p = 1.3%
- Δs/s = 0.2%
- Δt ≤ 100ps and 7 < t < 25ns

$$\text{mass resolution: } \frac{\Delta m}{m} = \frac{\Delta p}{p} \oplus \gamma^2 \left[\frac{\Delta s}{s} \oplus \frac{\Delta t}{t} \right]$$

(I+1)σ particle separation (100ps):
 η=0 η=1
 π/K 1.6 GeV/c 2.0 GeV/c
 (π/K)p 2.6 GeV/c 3.2 GeV/c
 (π+K+p)/d 4.0 GeV/c 4.8 GeV/c

Track Extrapolation

- TPC tracks only
- STAR full magnetic field $B_{\text{star}} = 0.5$ T
- $L(\eta=0) = 2.2$ m — $L(\eta=1) = 3.2$ m
- $\Delta p/p = 1.3\%$
- path length s (curvature $1/R$ from helix parameterization):

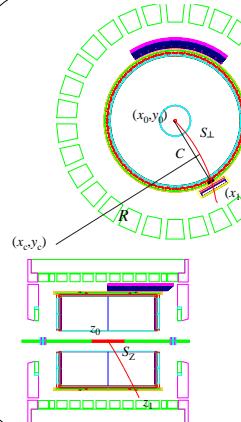
$$s = \sqrt{s_{\perp}^2 + s_z^2}$$

with

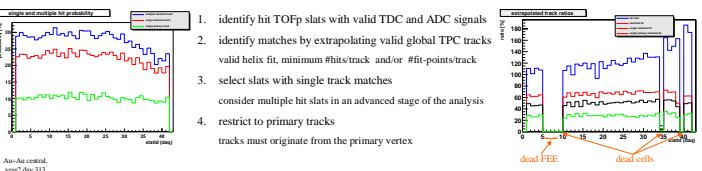
$$s_z = z_1 - z_0$$

$$s_{\perp} = 2R \arcsin(C/2R)$$

$$C = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2}$$

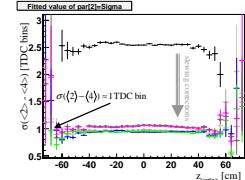


Track Extrapolation & Matching



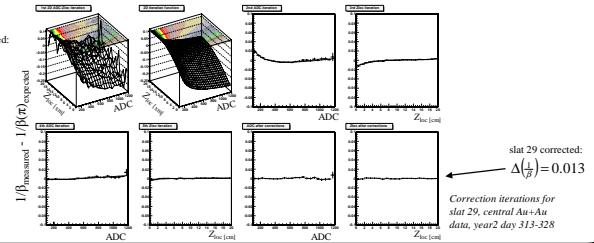
Start Time

- coincidence level in Au+Au: 2.AND.2
- complicated start corrections: large time-amplitude dependence (slewing)
- slewing corrections in terms of $\langle 2 \rangle - \langle 4 \rangle = \left(\frac{e_i + w_i}{2} \right) - \left(\sum_{j \neq i} \frac{e_j + w_j}{2} \right)$ with e_i, w_i : east-i, west-j pVVD channel in TDC-bins
- pVVD system resolution $\Delta t_{\text{start}} = 24$ ps
- equivalent single channel resolution ~58ps

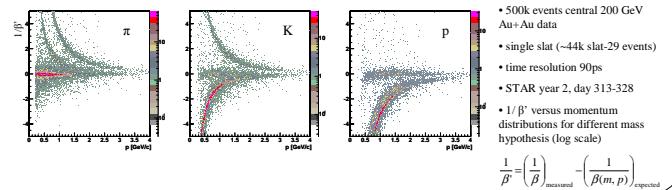


Stop Time

- 41 slats → individual sub-detectors, with different correction functions
- 7 dead channels: one FEE board (4 channels) and three HV-cells
- iterative hit-position and slewing corrections
 - slewing: $1/\beta$ dependence of ADC_i
 - scintillator propagation time: $1/\beta$ dependence of z_{local}



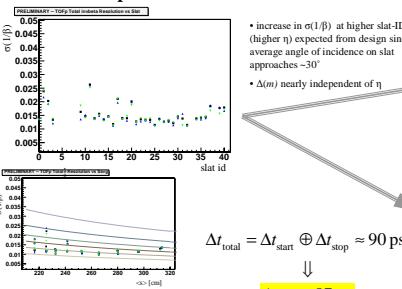
Identified Hadrons



- 500k events central 200 GeV Au+Au data
- single slat (~44k slat-29 events)
- time resolution 90ps
- STAR year 2, day 313-328
- $1/\beta$ versus momentum distributions for different mass hypothesis (log scale)

$$\frac{1}{\beta} = \left(\frac{1}{\beta} \right)_{\text{measured}} - \left(\frac{1}{\beta} \right)_{\text{expected}}$$

Resolution plots for all slats



Summary & Outlook

- calibrations nearly complete for Au+Au central
- other data sets to be analyzed:
 - Au+Au minimum bias (~1.4M events)
 - Au+Au central (single pVVD mode)
 - Au+Au at 20GeV (~280k)
 - p+p at 200GeV (~13M)
- physics goals
 - (m_{T}, y) spectra for π, K, p and d
 - various particle ratios \bar{p}/p , K/K^+ , π/π^+ , π/p and K/p
 - identified particle elliptic flow
 - ?deuterons
 - ? K^*, Λ, \dots daughter PID

